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THE ASCENT OF MAN.*

BY FRANK BAKER.

I think I could turn and live awhile with the animals—they are so placid and self-contained.
* * * * * *
They bring me tokens of myself * * *
I do not know where they got those tokens,
I must have passed that way untold times ago and negligently dropped them,
Myself moving forward then and now and forever.
Walt Whitman—1855.

The science of anthropology, one of the younger daughters of human knowledge, is so vast in its scope that to master all of its different ramifications seems a hopeless task. Having for its object the comprehensive study of man, including his origin, his development, and his present condition, its aim is to focus and co-ordinate the general results derived from a vast number of subordinate branches. The philologist contributes information concerning the origin and growth of language and its effect upon civilization, the mythologist tells of the psychological side of the human mind and traces the rise and progress of religious ideas, the archæologist, in order to fix their places in the history of mankind, searches for the remains of peoples long since passed away. All these depend for their material upon external records, left by tradition, by writing, by sculpture, or by implements and weapons.

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* Address of the Vice-President before the Section of Anthropology, American Association for the Advancement of Science, at the Indianapolis Meeting, August 20, 1890.

With greatest care every habitation of man is searched in order to learn from it the details of the life of its former inhabitants.

Within comparatively recent times still another avenue of information has been found, for we have learned that it is not alone by these external records that man's history can be traced, but that important facts may be obtained by studying the constitution of his body; that the changes and vicissitudes of his existence are recorded on his very bones, in characters long undeciphered but to which the clue has at last been found. My labors have led me more particularly to this department of anthropology, and a concise summary of the main heads of this research may be of value and interest.

The views propounded by Lamarck in the early part of this century, with reference to the modification of living organisms by use and adaptation, have been remarkably confirmed in modern times. Exhaustive researches into the constitution and properties of the cells composing living tissues show that they are subject to continual change, each impulse from without being registered by some small alteration in their physical condition. Impulses of a similar kind continuously acting produce greater changes, and long-continued repetition notably alters even the hardest and most enduring of structures. Thus it is that bones are modified in form by muscular pull, and the surfaces of teeth are shaped by incessant grinding. These alterations are more readily apparent to us because they affect very hard and easily preserved organs, but the effects are equally potent, though not so clearly recognizable, in the softer tissues of the body. Every act of our lives is certainly but surely registered within the marvelous structure of our bodies. Not a muscle can contract without an absolute change in its substance; not a nerve-cell can discharge without some self-destruction.

Most of these changes being very minute and evanescent are quite beyond our power to accurately estimate, and were the increments of change confined to a single lifetime—were each individual to stand only for himself and compelled to earn his experience by the same tedious struggle—use and adaptation would have but little power to mold mankind into races and varieties. But by the action of a law as yet imperfectly understood, the adaptations of each individual are transmitted to its offspring; or, to speak more accurately, the offspring pass through the changes more easily and quickly than the parent did. While each has always to go back to the beginning and commence from the simple blastema of the primitive egg, the younger has the advantage of being able to adapt itself more quickly to its surroundings, provided these have not too greatly changed, and thus starts a little way ahead of its ancestor in the race for life. In consequence of this law changes become cumulative, and a cause acting for a great length of time upon a series of successive generations finally produces a well-marked and easily observed effect in the structure of individuals—changing colors, modifying organs, shaping whole regions of the body.

Again, if, after such changes have been effected, these causes cease to operate and the organs they have shaped are no longer of use, the latter become reduced in size, atrophy and recede, remaining, however, in a vestigial condition for many, many generations as records of the past history of the race, as dolmens and cromlechs certify to former customs and flint arrow-heads and stone hatchets give evidence of a previous state of civilization.

The human body abounds in testimony of this sort—indications of the pathway by which humanity has climbed from darkness to light, from bestiality to civilization—relics of countless ages of struggle, often fierce, bloody, and pitiless.

These are found in every organ of the body, and each new investigation adds to their number. To enumerate them all would be impossible within the limits assigned me by your patience. I will therefore touch only upon a few of the more striking ones, especially those connected with the modifications of the limbs, with the erect position, and with the segmentation of the body.

The limbs, being organs of support and locomotion, show great variations in the zoological series, and the hand of man has long been looked upon as especially significant of his high position in the animal kingdom—one of the chief distinctions between him and the nearest brutes. To a certain extent this is correct. No creature possesses so highly complex and effective an organ for grasping and adjusting objects, and it is pre-eminently this that has made man a tool-using animal. On comparing a human hand with that of the anthropoids it may be seen that this efficiency is produced in two ways—first, increasing the mobility and variety of action of the thumb and fingers; second, reducing the muscles used mainly to assist prolonged grasp, they being no longer necessary to an organ for delicate work requiring constant readjustment. Thus some elements are added and some taken away. Now, according to the theory I have enunciated, the latest elements ought to show signs of their recent origin—to be somewhat imperfectly differentiated and liable to return to their primitive state, while those going out of active use ought to be vestigial, not equal in size or force to muscular organs generally, very liable to variation or disappearance. This is what actually occurs.

Among the new elements is a special flexor muscle for the thumb arising high up on the fore-arm. A very slight examination shows that this muscle has been split off from the fibres of the deep flexor that bends the terminal joints of the fingers. In most apes the two form a single muscle, and in man the thumb flexor very often shows unmistakable evidence of such origin. In about 10 per cent. of persons part of its fibres pass over and become blended with the parent muscle. Not infrequently I have seen the two entirely united, returning absolutely to their primitive condition. The deep and superficial flexors of the fingers show signs of a similar relationship, as they frequently blend more or less, tending to revert to the type shown in most lower animals. Indeed, if we go back to embryonic life we find all the muscles of the anterior part of the fore-arm united in what is termed the pronato-flexor mass, recalling the original condition of musculature in the earliest animals possessing limbs.

In the category of disappearing muscles comes the palmaris longus, an important aid in climbing and grasping. It takes its origin from the upper arm and passes to the hand, where it expands into a large sheet of thick membrane called the palmar fascia, which splits into several slips passing to each finger. The pull of the muscle acts upon all the fingers together, keeping them bent without independence of action. Now in man the fingers have each two separate flexor tendons that can act to a certain extent independently. To ensure their independence they are, at the wrist, enclosed in a remarkable tubular conduit or subway formed by soldering the palmar fascia to the wrist-bones. This at once destroys any effective action of the palmaris longus on the fingers and it becomes a flexor of the wrist. This soldering undoubtedly took place because the muscle was no longer required as a finger-holder. Like other organs that after playing a considerable part have come from change of habit to be of but little value, it shows the most astonishing tendency to variation. Not a week passes in a large dissecting room that some curious anomaly is not found in this muscle. Sometimes it is seen almost in its primitive condition, the palmar fascia being comparatively movable and the palmaris longus having some effect upon the flexion of the fingers; oftener it unites wholly or partially with some portion of the pronato-flexor mass or disappears altogether. The disappearance is usually only apparent, however. Regressive structures rarely disappear totally, for on careful search a strip of fascia can usually be found that represents the atrophied and aborted organ.

Since these two examples differ in that the first represents the development of a new muscle while the second is the atrophy of an old one, we ought to find racial differences corresponding to these two conditions. Our studies of racial anatomy are as yet far from sufficient to give us certain information upon these points, and I would especially avoid generalizing upon too meagre data. It has, however, appeared to me that in negroes the palmaris longus is more inclined to assume its primitive type—that is, to be less likely to vary—while the long flexor of the thumb is, on the contrary, more inclined to be partially if not wholly united with the deep flexor of the fingers.

Connected intimately with the hand are the other portions of the thoracic limb that carry it from place to place. Here again we may note many points indicating a progressive development of the member. When the arm is naturally and easily bent at the elbow it does not carry the hand to the shoulder, as might be expected, but towards the mouth. The reason for this is that the articular surfaces of the elbow-joint are not cut horizontally across the axis of the humerus but inclined at an angle of about 20°. This obliquity does not occur in the fœtus and is less in Bushmen, Australians, and the anthropoid apes. It is associated with another peculiarity; indeed, may be said to be caused by it. This is a twisting of the humerus on its axis, which occurs markedly in the higher races. If we hold up endwise the humerus of a European we see that the longest diameters of the upper and lower ends very nearly coincide. In the negro we find the lower diameter turned more towards the body; still more in the anthropoid apes, and again more as we descend the scale. Embryology teaches that the humerus was formerly set so that the hollow of the elbow looked backward rather than forward, and it seems, therefore, that, as the functions of the limb became more various, the lower end of the bone gradually twisted outward around the long axis until its diameter described a considerable arc. This turned the hand with the palm to the front, extended its range and adapted it for a wider usefulness. Greater twist is found in the right humerus than in the left and in the humeri of modern times than in those of the stone age. As the torsion increased some provision became necessary for carrying the hand easily across the body to the mouth. This was effected by the inclination of the trochlear surface of the elbow-joint already adverted to.

Many movements of the arm in man are produced by muscles acting upon the shoulder-blade or scapula. As the hand was turned outward and a wider range given, these increased in extent and importance, and the scapula accordingly widened out at its vertebral border in order to give a more extensive attachment for muscles. In order to accurately estimate this change the ratio of the breadth to the length of the scapula is taken. This ratio, called the scapular index, is highest among the white races, less in the infant, in negroes, and in Australians, and still less in anthropoid apes. It is significant also that the vertebral border of the scapula is the last to form in the fœtus. We have, therefore, three modifications—the torsion of the humerus, the inclination of its trochlear surface, and the scapular index—all depending upon each other, all varying together *pari passu,* and all showing a progressive development both in the individual and the race.

Muscle is composed of one of the most highly organized and expensive tissues of the body. Unless fed constantly with a great supply of blood to keep up its active metabolic changes, it quickly wastes, functional activity being absolutely necessary to its proper maintenance, as any one knows who has seen how rapidly the muscles of an athlete diminish when he goes out of training. If from accident or change of habit its use altogether ceases, its protoplasm is gradually removed, its blood-supply diminishes, and it shrinks to a mere band or sheet of fibrous tissue. Changes of function may therefore affect the form of muscles, one portion becoming tendinous or fascia-like; may even cause them to shift their places by inducing a development on one side and an atrophy on another, or to disappear altogether, replaced by fascia or ligament. A similar regression may take place in bone and cartilage, a high grade, actively metabolic tissue, difficult to maintain, being replaced by a low grade one comparatively slow to change. It is, therefore, not unusual to find that muscles, bones, and cartilages performing important functions in some animals are represented by vestigial structures in those higher in the scale. Our conclusions on this subject are confirmed by finding occasional instances where the hereditary tendency has been greater than usual and the parent form is reproduced more or less completely in the higher animal. The palmar fascia at the distal end of the palmaris longus, to which allusion has been made, represents a former muscular portion, relics of which probably remain as some of the small thumb muscles.

Another interesting instance is the epitrochleo-anconeus, a small muscle at the elbow-joint, used in apes to effect a lateral movement of the ulna upon the humerus. In man the ulna has become so shaped that the lateral movement is almost totally lost, and the muscle has accordingly degenerated, being represented by a strip of fascia. Very often, however, a few muscular fibres are still found in this situation.

Several minor peculiarities that remind us of primitive conditions occur in the region of the humerus. Occasionally a supracondyloid process is found throwing a protecting arch over the brachial artery and median nerve; in this resembling the supracondyloid foramen of marsupials. Struthers found this to be hereditary, occurring in a father and four children. A perforation of the olecranon fossa may probably be regarded as a reversion towards the condition of anthropoid apes. This frequently occurs in South African and other low tribes and in the men of the stone age. Recently Dr. D. S. Lamb has found it remarkably frequent in prehistoric Indian humeri from the Salado Valley, Arizona.

While the region of the hand and fore-arm indicates increased of specialization, the upper part of the limb generally testifies to a regression from a former more highly developed state. The anatomy of the flying apparatus of a bird shows a series of muscular, ligamentous, and bony structures connected with its upper arm far beyond anything ever seen in man. The coracoid bone, a very important element of the shoulder girdle in birds, has become reduced in man to a little vestigial ossicle that about the sixteenth year becomes soldered to the scapula as the coracoid process. The muscles arising from this—pectoralis minor, coraco-brachialis, and biceps—are structures represented in birds by strong, flying muscles. The subclavius, a little slip ending at the clavicle, appears to have formerly passed to the coracoid bone or to the humerus and been employed in arm movement. The pectoralis major appears to represent what was formerly a series of muscles. All these have a tendency to repeat their past history, and the number of variations found among them is legion. The biceps shows traces of its former complexity by appearing with three, four, or even five heads, by a great variety of insertions, by sending a tendon outside the joint capsule instead of through it, as is the rule. The pectoralis major may break up into several different muscular integers, inserted from the shoulder capsule down to the elbow. The coraco-brachialis shows the same instability, and by its behavior clearly indicates its derivation from a much larger and more extensive muscular sheet.

Not less significant are the ligaments about the shoulder. Many of these appear to be relics of organs found active in animals lower in the scale. Thus the coraco-acromial ligament spanning over the shoulder-joint is probably a former extension of the acromion process; the rhomboid, conoid, trapezoid, and gleno-humeral ligaments represent regressive changes in the subclavius muscle, the coraco-humeral ligament, a former insertion of the pectoralis minor. Bands of the deep cervical fascia alone remain to testify to the former existence of the levator claviculæ, a muscle present in most mammals and used to pull forward the shoulder girdle when walking in a quadrupedal position. In negroes I have frequently found it more or less complete. A fibrous strip uniting the latissimus dorsi to the triceps is all that remains of an important muscle, the dorso-epitrochlearis, passing from the back to the elbow or fore-arm, used by gibbons and other arboreal apes in swinging from branch to branch. Testut found this fully developed in a Bushman. I have myself seen various muscular slips that must represent some portion of it, and authors generally describe it as occurring in 5 or 6 per cent. of individuals.

The hind limbs of apes are popularly thought to be remarkably specialized. The term quadrumana or four-handed is used to characterize the class; yet it is quite true that this term involves a false conception. No animal has four exactly similar feet, still less four hands. The feet of the ape differ widely from hands; the great toe is not really opposable like the thumb, but merely separable from the others and differently set, so as to afford a grasp like that of a cramp-iron. The gibbon alone has a small muscle of the foot that may be compared with the opponens of the thumb. That these peculiarities are also shared by man to some extent is also well known. It is quite possible to train the toes to do a certain kind of prehensile work, even to write, cut paper, and sew. A baby not yet able to walk can often pick up small objects with its toes. Compare the marks caused by muscular action on the sole of a baby's foot with those on the hand, and it will be seen that there are distinct signs of this prehension. Even the opponens hallucis of the gibbon is not infrequently found in man. The fœtal condition of the foot also approaches that of the apes, the heel being shorter and the joints so arranged that the sole can be easily turned inward. In the ape the first or great toe is turned backward and outward by shortening its metatarsal bone and setting it obliquely upon the ankle. This shortening and obliquity also occur in the fœtus; the adult condition, in which the metatarsal bone is lengthened and set straight so as to give a longer and firmer internal border to the foot, being gradually acquired. Many savage tribes still use the foot for climbing and have a shorter metatarsal, a wider span between the first and second toes, and greater ease in inverting the sole. Connected with this ease of inversion should be mentioned a peculiar, ape-like form of the tibia that occurs in people of the stone age, in the mound-builders, and in some American Indians. This is a flattened, sabre-like condition of the bone known as platycnemy. It is apparently to give greater surface of attachment and resistance to the pull of the tibialis anticus, the principal muscle that turns the sole inward. It is interesting to note that this peculiarity is much more marked in some early human skeletons than in any of the anthropoids.

The poet says that while other animals grovelling regard the earth, Jupiter gave to man an uplifted countenance, and ordered him to look heavenward and hold his face erect towards the stars.

> "Pronaque cum spectent animalia cetera terram,
> Os homini sublime dedit, cœlumque tueri
> Jussit, et erectos ad sidera tollere vultus." *
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> *Ovid, Metamorphoses : I, 84–86.*

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* Compare Milton :

"A creature who not prone
And brute as other creatures, but endued
With sanctity of reason, might erect
His stature, and upright with front serene
Govern the rest, self-knowing."

Paradise Lost: VII, 506–510.

The erect position is, however, gradually acquired. As in the sphinx's riddle, we literally go on all fours in the morning of life, and the difficulty that an infant experiences in learning to walk erect is strong evidence that that is an accomplishment acquired by the race late in its history. We ought, if this is the case, to find in the human body indications of a previous semi-erect posture. There is a vast amount of evidence of this character, and I can only sketch the outlines of it.

The erect position in standing is secured by the shape of the foot, by the attachment of strong muscles at points of severest strain, and by the configuration of the great joints which permits them to be held locked when a standing posture is assumed. All these features are liable to great variation; they are less marked in children and in the lower races. Let us examine them somewhat more carefully.

The Caucasian type of foot is evidently that best adapted for the erect position. The great toe is larger, stronger, and longer than the others, making a firm support for the inner anterior pier of the arch formed by the bones—an arch completed by a well-developed heel and maintained by a strong dense band of fascia and ligament binding the piers together like the tie-rod of a bow-string truss—thus producing a light and elastic structure admirably adapted to support the weight of the body and diminish the effect of shocks. In the lower races of man all these characters are less marked. The great toe is shorter and smaller, the heel-bone less strongly made, the arch much flatter. This flattening of the arch produces the projection of the heel found in some races.

The muscles required for maintaining the erect position are those which from our predilection for human anatomy we are apt to call the *great* extensors, overlooking the fact that in other animals they are by no means as well developed as in man. Being required at the points of greatest strain, all are situated on the posterior aspect of the body—the calf, the buttock, and the back.

A very slight examination of any lower animal will show how strikingly it differs in the muscular development of these regions. The great muscle of man's calf, the triceps extensor suræ, is formed by the welding together of some four muscles separate in many lower forms. Varieties are found in man showing all grades of separation in these elements. One of the muscles, the plantaris, was formerly a great flexor of the toes, the plantar fascia representing its former distal extent. Like the palmaris of the arm it lost its original function by the welding of the fascia to the bones to secure the plantar arch, and its functions being then assumed by other muscles it began to dwindle, and is now represented by a mere vestigial rudiment of no functional value. It is well known that the lower races of men have smaller calves than Europeans. Again, it should be noted that as the erect position is assumed the muscles required for the flexion and independent action of the toes become reduced in character. A comparison with other forms shows that some of the small muscles now confined to the region of the foot formerly took their origin higher up, from the bones of the leg. Losing in functional importance, they have dwindled in size and gradually moved downward.

The great glutæi muscles of the buttock find their highest development in man. They are subject to similar variations. Certain muscles of this region, normal in apes, are occasionally found in man—a separate head of the great glutæus, derived from the ischium, and the scansorius, or climbing muscle, that assists the great flexor of the thigh (the ilio-psoas) may be mentioned.

The enormous size and complexity of the muscles of the back in man are well known. The erector of the spine fills up the vertebral grooves and sends up tendons along the back like stays supporting the masts of a ship. The mass of this muscle is comparatively less in anthropoids.

Notwithstanding all these powerful muscles, it would be impossible to retain the erect position for any great length of time were we to depend upon them alone, for it requires as before stated, a great expenditure of force to keep a muscle in active use. It becomes rapidly fatigued and then loses its power, as any one may prove by standing in any constrained position, even "in the position of a soldier," for half an hour. To provide against this a beautiful arrangement of joints and ligaments has been developed.

When in the erect attitude the ankle-joint is so arranged that its bones are in a position of greatest stability, and the center of gravity is so adjusted that it falls directly upon it. This reduces to a minimum the amount of muscular force required to keep the body erect. At the knee the center of gravity falls a little in front of the axis of the limb, and the back and sides of the joint are provided with check ligaments or straps that hold the joints locked in a position of hyper-extension, so that no muscular force whatever is used to maintain it. These ligaments are regressive structures, being vestiges of former insertions of muscles near the joint. At the hip a similar condition occurs, the center of gravity falling behind the joint and the whole weight of the trunk being hung upon the ilio-femoral ligament. This structure is much more marked in man than in other mammals, and is found to vary considerably in its size and strength.

The spinal column has been remarkably modified to adapt it to the erect position. Before the fifth month of uterine life the whole spine describes a single, large, dorsally directed curve like that of the quadruped, arranged to accommodate the viscera. As this would be incompatible with the erect posture, two additional curves in the opposite direction are formed—one in the region of the loins just where the center of gravity would begin to fall forward, another in the neck to counteract the heavy and unstable weight of the head. These curves are gradually acquired. While possessed by all races, and in a less degree by the higher apes, they arrive at their highest development in Europeans. Careful measurements show that the shapes of the vertebræ have been gradually modified. There is no abrupt transition from the spine of the lowest savages—Australian, Bushman, Andaman—to that of the gorilla, gibbon, and chimpanzee, and the lumbar curve of the lower races of men is much better adapted to running in a semi-erect position through the jungle or bush.

There is also evidence that the posterior limbs have moved forward upon the spinal column in order that the erect position may be assumed with less effort. In man there are between the skull and the sacrum twenty-four vertebræ. The other primates have usually twenty-six, although the gorilla, chimpanzee, and orang agree with man. Now in fœtal life the attachment of the hip-bones to the sacrum commences from below upward. Union first occurs with the third sacral vertebra, leaving twenty-six presacral, then advances forward, the first sacral uniting last of all The hip-bones actually move up along the spine a distance of two segments. Occasionally this shifting is carried still farther, and but twenty-three presacral vertebræ are left. Anomalies caused by an arrest of development at some stage of this process are not at all infrequent. The most common is the want of union between the hip-bones and the first sacral vertebra, thus producing apparently six lumbar vertebræ. A most beautiful specimen of this anomaly was found last winter in my laboratory.

The spine is sustained erect by stringing from vertebra to vertebra numbers of short ligaments that reduce to a minimum the muscular exertion required to support it. These are particularly numerous between the spines along the great dorsal curvature. Some of these ligaments are replaced by small muscles, very inconstant and variable, the survivals of a whole system of musculature that had for its object the moving of the separate joints of the spine, one upon another.

The head is also much modified by the erect position. In quadrupeds its suspension requires an extensive apparatus, a large, strong, elastic strap—the ligamentum nuchæ—passing from the tips of the thoracic vertebræ to the occiput, sending processes to all the neck vertebræ involved in the strain. Though need for it has in great degree ceased, since the head has become poised in such a way as to involve but little expenditure of muscular force, yet relics of this great suspensory apparatus remain in man's neck in the form of thickened fascial bands.

The arrangement of the great foramen of the skull that transmits the central axis of the nervous system, the spinal cord, is necessarily different in an animal carrying its head erect. The foramen would naturally tend to be set forward, more under the center of gravity, and its inclination would be more nearly horizontal. Here again we see that the ideally perfect form is more nearly approached in the civilized races. It is never quite realized, and indeed the whole skull and its contents evince markedly that they are still undergoing an evolution. Again the lower races show variations that unite them with the anthropoids. While a negro may have a foramen magnum inclined 37° to the horizontal, the orang may fall to 36°.

But it is not only in this way that we get evidence that the erect position has been gradually acquired. Since gravity plays an important part in the functions of the visceral and circulatory systems, any marked change in the line of equilibrium must necessarily be accompanied by disturbances. These disturbances, to a certain extent, conflict with the acquirement of the position; as they weaken the animal. In the course of time the body may perhaps become adapted to the changed conditions, but before that perfect adaptation takes place there is a period of struggle. There is abundant evidence that such a struggle has occurred and is yet going on; the adaptation being as yet far from complete.

The most striking and important of these adaptations concerns the pelvis. When the erect posture is assumed, the weight of the viscera being thrown upon this bony girdle, it becomes adapted for their support by becoming more fixed and dish-like in shape. This is naturally more pronounced in the female, since with her the pelvis must bear the additional weight of the pregnant uterus. It is evident that a solid, unyielding, laterally expanded ring of small aperture would give the most effective support in the erect position, but it is equally clear that with any such structure parturition would be impossible. In the quadruped the act of parturition is comparatively easy, the pelvis offering no serious hindrance. The shape of the female pelvis is therefore the result of a compromise between two forms—one for support, the other for ease in delivery. When we reflect that along with the acquirement of the erect position the size of the head of the child has gradually increased, thus forming still another obstacle to delivery and to the adaptation which might otherwise have taken place, we can realize how serious the struggle has been, and no longer wonder that deaths in child-birth are much more common in the higher races, and that woman in her entire organization shows signs of having suffered more than man in the upward struggle.

In no other animal is there shown such a distinction between the pelvis of the male and that of the female—a distinction that increases as we ascend the scale. While the amount of individual variation is great, we yet see, particularly in the pelvis of the Andaman Islanders and of the Polynesian races, distinctly anthropoid characters. The scanty material at hand indicates that a similar transition occurred between the modern and prehistoric types. The approximation of the infantile and simian forms is well known.

The pelvis alone does not suffice to support the viscera. In quadrupeds the whole weight is slung from the horizontal spine by means of a strong elastic suspensory bandage of fascia, the tunica abdominalis. The part of this near the thorax has in man entirely disappeared, being no longer of any use. In the groin it remains to strengthen the weak points where structures pass out from the abdominal cavity. That it often is insufficient to withstand the great pressure is testified by the great prevalence of hernia, another sign of imperfect adaptation. The frequency of uterine displacements, almost unknown in the quadruped, has also been noted. It is significant that one of the most effective postures for treating and restoring to place the disturbed organ is the so-called "knee-elbow position," decidedly quadrupedal in character.

Many other indications are found in the viscera. The urinary bladder is so arranged in man that any concretions do not gather near the opening of the urethra where they might be discharged, but fall back into the cul-de-sac at the base, where they enlarge and irritate the mucous lining. The cæcum, with its vermiform appendage, a vestigial organ finding its proper functional activity far below man, is so placed in quadrupeds that the action of gravity tends to free it from fœcal accumulations. In man this is not the case, and as a consequence inflammation of this organ or its surrounding tissues, very serious and often fatal, is by no means rare. It may be noted that the ascending colon is obliged to lift its contents against gravity, and that in a lowered state of the system this might very readily induce torpidity of function.

The gall bladder in quadrupeds also discharges at an advantageous angle. In man, although the difference is slight, it appears to be sufficient to cause at times retention and consequent inspissation of the bile, leading to the formation of gall-stones.

The quadruped's liver hangs suspended from the spine, but as the erect attitude is assumed it depends more and more from the diaphragm. The diaphragm in its turn develops adhesions with the fibrous covering of the heart, which is continuous with the deep fascia of the neck, so that in effect the liver hangs suspended from the top of the thorax and base of the skull. This restricts in some degree the action of the diaphragm and confines the lungs. This must have an effect upon the aeration of the blood, and consequently upon the ability to sustain prolonged and rapid muscular exertion. An extra lobe of the right lung that in animals intervenes, either constantly or during inspiration, between the heart and the diaphragm, is occasionally found in a vestigial state in man.

The vascular system abounds in evidences that it was primarily adapted to the quadrupedal position. By constant selection for enormous periods of time the vessels have become located in the best protected situations. It is scarcely possible to injure a vessel of any size in an animal without deeply penetrating the body or passing quite through a limb. In man, on the contrary, several great trunks are comparatively exposed, notably the great vessels of the thigh, those of the fore-arm, and of the ventral wall.

The influence that gravity has upon the circulation is well known.

The horizontal position of the great venous trunks favors the easy flow of blood to the heart without too greatly accelerating it. Man, in whom these trunks are vertical, suffers thereby from two mechanical defects—the difficulty of raising blood through the ascending vena cava, whence come congestion of the liver, cardiac dropsy, and a number of other disorders, and the too rapid delivery through the descending cava, whence the tendency to syncope or fainting if for any cause the action of the heart is lessened. Clevenger's admirable discovery that the valves of the veins are arranged for a quadrupedal position should also be mentioned here. Evidently intended to resist the action of gravity, they should, to be effective, be found in the large vertical trunks. But in the most important of these they are wanting; hence are caused many disorders arising from hydrostatic pressure, such as varicose veins, varicocele, hæmorrhoids, and the like. Yet they occur in several horizontal trunks, where they are, as far as we know, of no use whatever. Place man on all fours, however, and it is seen that the entire system of valves is arranged with reference to the action of gravity in that position. The great vessels along the spine and the portal system being then approximately horizontal do not require valves, while all the vertical trunks of considerable size, even the intercostal and jugular veins, are provided with them. A confirmation of this view is found in the fact that the valves are variable in character and tend to disappear in the veins where they are no longer needed.

Every animal possessing a back-bone may be said to consist of a series of disc-like segments, arranged on a longitudinal axis. These segments are originally similar in character, but become specially modified in innumerable ways to meet the needs of the individual. Anatomists conclude, upon surveying the whole field, that this indicates a derivation of the vertebrates from some form of the annelid worms, among which a single unit produces by successive budding a compound longitudinal body. This view is fully confirmed by the behavior of the human embryo.

The number of the segments varies considerably, rising sometimes to as many as three hundred in some fishes and reptiles, and being generally greater in the animals below man. There are many indications, however, that in man, segments formerly possessed have disappeared. Leaving the skull for the present out of account, there are in the adult thirty-three or thirty-four vertebræ that may be held to represent these segments; the additional vertebra, when it occurs, almost invariably belonging to the coccygeal or caudal series. In the human embryo thirty-eight segments can at one time be made out. Four or five of these generally disappear, but cases are by no means wanting in which they remain until after birth and constitute a well-marked free tail. In one case, carefully examined and described by Lissner, a girl of twelve years had an appendage of this character 12.5 centimeters long. Other observers, probably less careful and exact, report much greater lengths. From some observations it would appear that abnormities of this kind may be transmitted from parent to offspring.

Dr. Max Bartels recently collected from widely scattered literature reports of 116 actually observed and described cases of tailed men. In 35 instances authors reported such abnormities to be possessed by an entire people, they themselves having observed certain individuals. These cases are scattered throughout the whole of the known globe and extend back for a thousand years. When we consider that the authenticity of many cases is beyond question, and that the number that escaped accurate observation and report must be much greater, we can see that we are not dealing with so rare a phenomenon as would at first be supposed.

Other regressive structures are abundant in this region. The spinal cord in its earlier state extended the entire length of the vertebral canal. In the child at birth it occupies only 85 per cent. of that length; in the adult 75 per cent. This is due mainly to the more rapid growth of the spine. There stretches, however, from the lower end of the cord down to the very end of the spine a small thread-like structure, the filum terminale, a degenerated vestige of the lower caudal part of the spinal cord. Wiedersheim suggests that the frequent occurrence of degenerative disorders in the lower end of the adult cord may be due to a pathological extension of the normal atrophy. Rauber found in this region traces of two additional pairs of spinal nerves. The vessel that runs down in front of the sacrum and coccyx corresponding to the caudal artery of quadrupeds shows signs of a former more extensive distribution, as it ends in a curiously convoluted structure known as the coccygeal gland, containing vestiges of vascular and nervous tissues. Traces of caudal muscles still remain, notably the ischio-coccygeus, which in animals moves the tail sideways, and the anterior and posterior sacro-coccygeus, for flexing and extending it. Occasionally the agitator caudæ is found as a muscular slip passing from the femur to the coccyx. These muscles cannot be of any value in man, as the coccyx is practically immovable. At the point where the end of the spine was primarily attached to the skin a dimple is formed by regressive growth, and here the direction of the hairs also shows an aborted organ.

Another interesting condition connected with segmentation is the varying number of ribs. Most mammals have more ribs than man, and as we descend in the scale they continue to increase. A study of development indicates that a rib is probably to be considered as an integral portion of a vertebra. As the arch of a vertebra encloses the central nervous system, so the ribs enclose the visceral system. If this be correct they ought to be found throughout as far as the body cavity extends. This is really the case. They exist in the neck as the anterior bars of the transverse processes, in the loins as the transverse or costal processes themselves, in the sacrum welded together into what are known as the lateral masses. A great number of considerations derived from comparative anatomy, from embryology, and from variations found in the adult combine to support these conclusions.

Nothing would seem less likely at first sight than that the capacious expanded brain-case or skull with its complicated structure should be composed of segmental pieces like the vertebræ; yet there is no doubt that the poet Goethe was on the right track when he made that important generalization. The details of the segmentation are very far from being worked out, but a vast amount of evidence indicates that the general conclusion is correct.

Since the predominant necessity in the construction of the skull is to afford a protection for the brain, we need not be surprised to find that it is very greatly modified in man. Enormous labor has been bestowed upon craniology in an attempt to separate definitely the races of men as well as to connect them with the lower forms. The success in establishing races has not been such as was anticipated. A constant intergrading of forms defies all attempts at a hard and fast classification. We also see types that intergrade between anthropoids and man, and find abundant evidence that the human skull was derived from a form similar to that of still lower mammals.

At first man's skull seems to be much simpler than the typical form. The bones are fewer and less complicated. But follow back the course of development and we find the bones separating—the frontal into two pieces, the occipital and temporal each into four, the sphenoid into eight, repeating what we find as we descend the vertebrate scale.

Many of these peculiarities may remain throughout life. Such are the interparietal bone, found very frequently in ancient Peruvian and Arizonian skulls; the division of the frontal and temporal bones each into two, the persistence of the intermaxillary bones and of that division of the cheek or malar bone known as the os japonicum. Even cleft palate, a deformity and defect in man, merely reproduces a state natural to some of the lower mammals.

There are also present structures that are homologous with the so-called visceral arches represented in the thorax by ribs. Such are the lower jaw, the hyoid bone, and the thyroid cartilage. A study of the embryo shows us that these are portions of a series of bars primitively arranged on the plan of the branchial apparatus of the water-breathing vertebrates. Each bar has its appropriate skeleton and vascular supply, and is separated from the contiguous ones by a cleft that at first passes entirely through the soft tissues and communicates with the primitive visceral cavity. These clefts may persist and cause serious deformities. The skeleton of the mandibular and hyoid bars is remarkable as containing indications of elements present in the lower vertebrates. In fishes the lower jaw articulates with a large bone apparently not found in mammals, but on tracing carefully the development of the mammalian skull it is found that this bone is represented by the incus, one of the minute ossicles of the ear. In the fœtus the primitive lower jaw, in the shape of a bar of cartilage, actually extends into the ear cavity and the upper end of it remains as the malleus. Relics of the hyoid or second branchial arch are also found—the styloid process of the temporal bone being one of them.

The capacity of the cranium is usually held to distinguish man remarkably, yet the lowest microcephali approach the apes in this respect, and the lower races have unquestionably smaller brains than the higher. As far as can be judged, there has also been an increase in average capacity during historic times. One fact pointed out by Gratiolet is very significant. In monkeys and in the inferior races the ossification of the sutures commences at the anterior part of the head, while in Europeans these sutures are the last to close. This would indicate a greater and longer continued increase of the frontal lobes of the brain.

The same remarks may be made concerning the facial angle and prognathism. While by none of the different angles proposed have we been able to definitely separate distinct races, yet we find that the angle of the lower races and of microcephali approaches that of the anthropoids, and that as the capacity of the skull has increased the jaw has been thrust back under it to support the weight. This shortening of the jaw gives the characteristic expression of the civilized face. We at once recognize a brutal physiognomy by the projection and development of the great masticating apparatus, used in most animals near man as a formidable weapon of defense. The shortening has produced some very remarkable changes. It has shoved the third molar or wisdom tooth so far back that it is crowded against the ascending part of the jaw, thereby occasioning disturbance and trouble in its eruption. Being no longer practically useful, it tends to disappear, and many people never cut any wisdom teeth. Among the Australasians, on the contrary, a fourth molar is not infrequently found, and rarely in European skulls. Evidences also exist of a lost incisor in the upper jaw on each side. Dental follicles form for it and usually abort, but occasionally the tooth appears fully developed in the adult. The great canines or eye-teeth, used in apes and other animals for tearing and holding, are in them longer and larger than the other teeth, and room is made for them in the opposite jaw by leaving an interval, called the diastema, between the canine and the tooth next to it. These large projecting canines have disappeared in the normal human skull and the diastema has accordingly closed up. Yet it is by no means uncommon to see the whole arrangement reappear, especially in low-type skulls. Projecting canines or "snag teeth" are so common in low faces as to be universally remarked, and would be oftener seen did not dentists interfere and remove them. It may be noted also that the muscle that lifts the lip from over the canines and bares the weapon often reappears in man and is used in snarling and disdainful expressions.

Many details of structure of the skull point in the same direction. Occasionally the occipital bone has a third condyle as in some other mammals or a large lateral projection like that of a vertebra, the paramastoid process, or indications of a separate centrum (*os basioticum* of Albrecht). It may have interiorly a hollow (*fossette vermienne*) for the vermiform process of the cerebellum, and exteriorly a large transverse ridge (*torus occipitalis*) for the insertion of the muscles of the nape. All these peculiarities are more frequent as we descend the scale, whether we regard the lower races of man, microcephalic individuals, or lower animals. Like many of these atavistic features they are also more common among the criminal classes.

I have omitted the discussion of many important structural features that mark various stadia in man's ascent. From the muscular system alone there could be adduced a very great number of instances of the survival of primitive forms and of progressive variations, particularly in the development of the muscles of the face and breast. In the osseous system also there are many such, among which may be mentioned the episternal bones, the central bones of the wrist and ankle, and the os acetabuli. The exact significance of these is still under discussion, as is also the question of supernumerary digits that sometimes appear on the hands and feet.

Additional instances might be drawn from the visceral system. The larynx contains small throat pouches like the great air sacs of the anthropoids. The pharynx of the embryo is lined with cilia like that of the very lowest vertebrates. Traces of the primitive intestine are shown by the peculiar distribution of nerves and the folding of the peritoneum. The liver and spleen both occasionally indicate a previous simpler condition, and the intestine has sometimes diverticula of no functional use—indeed, likely to be disadvantageous—yet pointing to a previous state. These anomalies never occur at random, but can be explained consistently upon the theory of reversion.

The genito-urinary system abounds in them. The uterus may have two cavities, as in many quadrupeds, or approach that condition by being bicornuate, as in apes, and a great variety of other vestigial structures occur, all pointing back to an original neutral condition, before the sexes were differentiated.

In the nervous system there is no lack of instances. Our studies of the brain are as yet far from complete—indeed, we seem to be only at the threshold of a reasonable knowledge of the nervous centers—and the crowd of names, the inextricable maze of synonymy that now obscures that region is only a mark of our ignorance. It is a case of "*omne ignotum pro mirifico*"—ignorant of the true value of the parts we examine, we have named even the most insignificant details of structure. Perhaps one of the most interesting results of modern research is the conclusion that the psychic life of our ancestors must have been different from our own, since they possessed organs of sensation differing in degree and probably in kind. The sense of smell as indicated by the size of the olfactory bulbs of the brain is decreasing in acuteness. The fœtal brain posseses comparatively larger bulbs, as do also the brains of lower races and of anthropoids. The sense, being no longer required for the preservation of the species, is slowly becoming dulled. Jacobson's organ, a curious structure found in many mammals, combining in some unknown manner the olfactory and gustatory senses, occurs in a vestigial state in man, and the duct connecting it with the mouth yet remains as the anterior palatine canal. The pineal and pituitary bodies of the brain probably represent obliterated sense organs, the former being an eye, the latter having some connection with the pharynx. Our other senses have also been modified. The eye has a rudimentary third eyelid, such as birds and lizards possess, covered with minute hairs. The external ear shows signs of derivation from the pointed ear of quadrupeds and abounds in vestigial muscles such as they use for controlling and directing it.

From this rapid sketch it will be apparent to you that the evidence that man's path upward has led along the same route traveled by other animals is now very powerful in its cumulative weight. By no other argument can we satisfactorily explain the bewildering maze of resemblances; yet when called upon fix the exact line by which we have reached our present estate we at once meet with serious difficulties. It is a popular misconception that there has been a regular chain-like series, with now and then a "missing link." The various races of men and the anthropoids are merely one branch of the great tree Yggdrasil, that overshadows the whole earth and reaches up into heaven. The individuals that we compare occupy the terminal twigs of that branch, being not related directly but only as springing from a common stock. The fact that resemblances occur does not necessarily prove a lineal descent but rather a common ancestry. The races of man arose far back in prehistoric night. Each in its own way fought the struggle for existence. Favored more by climate, the Caucasian appears to have attained an intellectual superiority; yet it should not be forgotten that the others also excel, each in its own special way. The white races endure with difficulty the climate of the tropics, and without help would starve in the Australian bush and the Arctic ice-fields.

Notwithstanding all that I have said concerning reversive characters, we yet have hardly sufficient structural grounds for separating the races of man. Different varieties of the Caucasian race show marked variations. Between the lowest and most brutalized laborers and the cultivated and intelligent classes there exist anatomical differences as great as those which separate the white and the negro. The rapid change in the African races, remarkably shown in America in the three generations now before us, is a more conclusive proof of inferiority, as it indicates that they have not had time to acquire fixed characters.

Again, as to the anthropoids, it is evident that they have widely diverged from man, and that none represent the primitive ancestor from which all were derived. The comparison of a human skull with that of an adult gorilla or chimpanzee is very striking. On the one hand we see all the structural features subordinated to the necessity of forming a capacious receptacle for the brain; on the other, a similar subordination for producing an effective fighting apparatus—jaws, teeth, and ridges for the insertion of powerful muscles. In one, intelligence predominates; in the other, force. The skulls of the young of all these species show, however, much greater resemblances than those of adults. This seems to indicate that there must have been a primitive common type from which all have diverged. Savages when ill-fed and living in unfavorable conditions may simulate the habits of anthropoids, and this has an effect upon their physical structure, yet not on that account should we too readily accept their close relationship.

In this summary, I have purposely refrained from any discussion of the physiological phenomena that necessarily accompany anatomical structure. Yet these are most important. Anatomy and physiology are inseparable, each being dependent upon the other. The results of the erect position, of increased size of brain, of greater specialization of limbs, are almost incalculably great; so great that they affect the whole life of the animal—control his habits, direct his actions in war and in the chase, and finally mold peoples, nations, and races.

As Cuvier was able to deduce an animal's habits from the shape of his teeth, so we may speculate as to man's past and future from an examination of his anatomy. *Ex pede Herculem* has not ceased to be true. It would be impossible for me to adequately treat of all these results in one short hour; the subject must necessarily be deferred to another time and another place. If I have succeeded in showing you that structural features form no insignificant part of anthropology my object is attained.

"GENS" AND "SUB-GENS," AS EXPRESSED IN FOUR SIOUAN LANGUAGES.—The American Anthropologist for April, 1888, contained an article, "Meaning of the words for Gens in the Iroquoian and Algonquian Tongues," by Mr. J. N. B. Hewitt. He states that in nearly all the Iroquoian languages the word for gens also signifies clay or mud, and he finds a like peculiarity in the Algonquian. This is not the case with the four Siouan languages under consideration.

In Dakota, gens is o-tshe'-ti, *fire-place;* hence, one of the names which the Dakotas have given themselves, O-tshe'-ti shȧ'-ko-win, *seven fire-places,* comprising the seven original gentes, now tribes, Mdewakantonwan, Wakhpekute, Wakhpetonwan, Sisitonwan, Ihanktonwan, Ihanktonwanna, and Titonwan. The sub-gens is ti-o-shpa-ye, *a group of those who camp by themselves.*

The Omaha and Ponka call the gens tan'-wan-gdhan u-ba'-nan or tan'-wan-gdhan u-ba'-te, *a village* or *group of people springing from a common stock*—banan *and* bate, referring to *a clump of trees* springing from a common root or stump. All the gentes are described as tan'-wan-gdhan ba-nan'-nan, or tan'-wan-gdhan ba-te'-te. But their terms for *sub-gens* are tan'-wan-gdhan u-ki'-gdha-sne, *a segment of a village,* or, *one of the parts into which a stump has been split* (u-ga-sne), and u-ne'-dhe, *a fire-place.*

The Kansa have the term tan'-man u-ki'-pa-te, sociative in form, and therefore applicable to the *sub-gens* rather than to the gens.

The Osage tell of the Tsi'-shu u-tse' pe-dhŭn'-pa, the Han'ka u-tse' pe-dhŭn'-pa, and the Wa-ca'-ce u-tse' pe-dhŭn'-pa, all twenty-one gentes being in the Osage nation or confederacy. U-tse means *fire-place,* and pe-dhŭ^{n}-pa *seven.* There are fully sixty-seven gentes and sub-gentes among the Osage, that number of names having been gained, but the name for sub-gens is still unknown to the writer. Another Osage term for "gens" is u-pa-tse, which corresponds to the Omaha and Ponka ubate.

The Tciwere tribes (Iowa, Oto, and Missouri) call a gens ki-kra-tshe, as, Wa-ka^{n}' ki-kra'-tshe, *they call themselves* (*after a*) *Snake.* The name for *sub-gens* was not obtained, though each Iowa gens had four sub-gentes whose names have been recorded (excepting those of one gens), and there are still sub-gentes in one Missouri gens.

The Winnebago name for *gens* is i-ki'-ka-ra'-tsha-da, answering to the Tciwere kikratshe. Hence, Ta'i-ki'-ka-ra'-tsha-da, *the Deer gens.* No name for *sub-gens* has yet been found by the writer, though there are sub-gentes in the Bird gens. J. OWEN DORSEY.